# The Study of Solvent Laundering on Surface Dye-wash and Structures of Polyester Fabric

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**Abstract** Perchloroethylene (PCE), trichloroethylene (TCE), 1,1dichloroethylene (1,1DCE) and tetrachloromethane (TCM) with solubility parameter values of 9.76, 9.30, 9.28 and 8.65 respectively were used to pretreat polyethene terephthalate (PET) fibre in relaxed condition for varying times. Dyed polyester fabrics with known amount of dye uptake were also laundered in the chlorinated solvents at room temperature. The treated and untreated PET fibres were examined using critical dissolution time (CDT) technique in 100% phenol at 60°C in order to characterize the relative changes in their structure as a result of the treatments. The quantity of dye removed from the surface of the dyed fabric during laundering was determined spectrophotometrically while the washed surfaces were characterized by the use of X- ray diffractography (XRD), infrared spectroscopy (IR) and scanning electron microscopy (SEM) techniques. The TCM treated fibres gave the highest CDT value followed by TCE, 1,1 DCE and PCE treated fibres in that order. A trend of 1,1 DCE > PCE > TCE > TCM obtained for the level of liquid retained after treatments pointed to the closeness of solubility parameter values of the solvents to that of the PET as a major influence. TCM as solvent also gave the highest value of dye wash from the surface of the dyed fibre which may be explained in terms of its wider solubility parameter value to that of PET compared to PCE, TCE and 1,1 DCE with closer solubility parameter values. The low liquid retention values of TCM treated fibre is an indication of better dimensional stability as revealed by SEM and XRD results in terms of minimal swelling ability both in thickness and width while its high CDT value was an evidence of stability to deformation during processing and solvent cleaning where the fibre will be expected to become wet.

*Keywords*: *PET, solubility parameter, liquid retention, CDT, SEM, XRD, IR, dry cleaning*

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## 1. Introduction

Polyester is the most common fibre for majority of end-use applications and may take the form of fibre, yarn, fabric, film etc. PET has been reported to be the most common linear polyester applied in industry today [1,2]. Hydrophobic nature has made it desirable for light weight facing fabric used in the disposable industry and they provided perceptible dry feel on facing, even when the inner absorbent media is saturated. For any non-aqueous solvent to interact and modify the structure and possibly the properties of the PET fibres, they must be absorbed and retained within the polymer. The liquid wetting properties of fibrous materials are fundamentally important to their chemical processing and functional performance. The modified polyesters are prepared to overcome some drawbacks such as low moisture regain, static electricity and soiling problems which are interrelated and associated with hydrophobicity of the polyester. By making PET fibre hydrophilic, these drawbacks can be overcome and garments made from it will absorb perspiration and will wearing comfortable. This property is in response to one of the basic requirements of fabric worn next to skin that it should assist in moisture release to the atmosphere [3]. The presence of liquid within the polymer results in enhanced mobility of the polymer segments and an increased sensitivity of the chain molecules to any change in environmental conditions. When evaluating the effects of the solvents on the polymer, it is pertinent to know the amount of the liquid absorbed and retained because very high amount of liquid retained within the polymer can make the fibre to become unstable.

Structural modifications of polyethylene terephthalate (PET) depend upon the extent of interaction between polyester and solvents which is expected to be associated with their respective solubility parameter. Crystallization of polymers is a process associated with partial alignment of their molecular chains and they can crystallize upon cooling from the melt, mechanical stretching or solvent evaporation [4]. Several methods including X-ray diffraction, infra red (IR) spectroscopy, calorimetry, rheology, small angle X-ray scattering (SAXS) and critical dissolution time (CDT) have been reported by Gupta and

Kumar, [5], Buckley and Salam, [6], Gacen *et al.,* [7] and Chang *et al.,* [8] for the evaluation of the structural differences in the crystal morphology of PET fibres, however, the one considered to be common, simple, easy and direct among them is the critical dissolution time (CDT) technique [9], the measured value however depends on the method used and is therefore quoted together with the degree of crystallinity [10]. Critical dissolution time (CDT) technique measures the rate of dissolution of crystallites that developed in a polymer after treatments. Increase in the CDT values of the crystallized polyethylene terephthalate (PET) have been correlated with an increase in the crystal size developed on a fibre because CDT method assumes that crystallinity and crystal morphology are determining factors in dissolution of fibres. Crystallinity is an indication of the amount of crystalline region in polymer with respect to the amorphous content since polymer exist both in crystalline and amorphous forms [11]. The method used to determine the crystallinity or crystal morphology can be incorporated over time to measure the kinetics of crystallization in the polymer. The crystallization process of polymers does not always obey simple chemical rate equation but Johnson-Mehl-Avrami-Kolmogorov (JMAK) equation popularly known as Avrami equation and Lauritzen-Hoffman (LH) growth theory [12].

It was observed by Bendak *et al.,* [13], that the changes in CDT was less effective for samples thermally treated at temperatures up to 160°C and suggested a nucleation tendency of tiny crystallites for this behaviour. They also reported that treatment of PET fibres under constant length resulted in smaller CDT values than those attained by free conditions. Galil, [14] found that CDT of polyester in phenol or phenol/tetrachloromethane mixture was extremely sensitive technique for measuring fibre crystallinity and for detecting small morphological differences between untextured and textured fibres, the fraction of the ordered molecules in polymer is characterized by the degree of crystallinity which typically ranged between 10% and 80%.

The crystallization usually obtained as a result of either thermal or chemical energy on the polymer leads to the modification of both the structure and properties of the polymer. Knox *et al.,* [15] viewed room temperature chemical annealing as similar to low ($< 175$°C) thermal annealing where small crystallites are formed, which confer negligible dimensional stability on the fibre undergoing shrinkage.

Dry cleaning or solvent cleaning is any cleaning process for clothing and textiles using a chemical solvent rather than water and with either of the two processes adequate care should be taken by the launderer to prevent shrinkage, loss of colour and fabric distortion. Contrary to the belief of many people, frequency of cleaning extends the life of a garment and helps to return garment to a like-new condition by removing stains and ground- in dirt and soils that ordinarily if left untreated could oxidize and cause yellowing of the textile materials.

Stripping of dye from dyed fibres is the reverse of the dyeing operation and the factors that influenced the dyeing of polyester are also expected to be crucial during extraction of dye from polyester [16]. The understanding of the dye wash in non -aqueous solvents is very useful because several disperse dyes have limited solubility in water and therefore some particulate disperse dye may still be occluded on the fibre surface after the dyeing phase is completed, if this condition is noticed, the last stage of the total dyeing process where surface dye is removed must be done. The most common and usual practical procedure for removing the unwanted dye from fibre surface using aqueous solution is called reduction clearing and provided the clearing temperature is not above the dye transition temperature (such as the room temperature used in this work), no dye will be stripped from within the polyester fibre. Some adverse effects of non-removal of excess dye on the fibre surface include reduction in wet fastness, dry cleaning fastness as well as dulling of shade. Polyester garments cleaned with materials that take longer time to dry may shrink thereby causing the garment to fit poorly and such garments may not be able to maintain its shape when dried because the suitability of fibres for a particular end use depends on several factors including strength, modulus, extensibility, chemical resistance, size, shape and surface tension; all these properties except surface tension and shape depends on the properties of the polymer that make up the fibre [17].

This research work is aimed at showing the effect which treating and laundering of dyed polyester fabric in selected chlorinated solvents will have on the surface morphology (SM) as well as surface dye-wash (SDW) of the fabric.

## 2. Methodology

### 2.1. Purification and Crystallization of PET Fibre

PET fibres were purified from spin finish by extraction with petroleum ether at 60°C for 1 h followed by scouring at 60°C in an aqueous solution of Lissapol (nonionic surfactant), washing and then drying under vacuum at 60°C for a further period of 24 h prior to use. A length of 20 cm of the purified polyethylene terephthalate (PET) fibre that had been attached to a constant weight of 0.5g (to remove tension and to straightening it) was measured and subjected to treatments in perchloroethylene (PCE), trichloroethylene (TCE), 1,1-dichloroethylene (1,1-DCE) and tetrachloromethane (TCM) at room temperature as well as heat setting process at 85°C for varying treatment times of 30, 60, 150, 300, 450, 600, 750, 900, 1800 secs respectively to generate ten (10) test samples for each treatment time. The treated samples were removed and air dried at room temperature.

### 2.2. Determination of Critical Dissolution Time (CDT)

The critical dissolution time (CDT) of the treated and untreated fibres was determined according to the procedure reported by Popoola and Johnson [18]. The fibres were hung one at a time from a stainless-steel spring attached to a wooden cork stopper and suspended freely in phenol (100%) contained in a Pyrex tube by means of a constant load of 0.5 g just sufficient to remove crimps. The tube was immersed in a water bath preset at 60$^o$C and

the time needed for suspension of the yarn in phenol till the falling off of the attached weight was recorded using a stop watch.

## 2.3. Liquid Retention Determination

The purified PET fibres weighing approximately between 30-50 mg each were pre dried at 105°C for 2 hr in a vacuum oven and then in a dessicator containing silica for additional 24 hr to ensure adequate removal of moisture prior to liquid treatment and retention studies at 60°C [19]. The samples were then weighed using O'haus Adventurer (TM model) electronic balance and subsequently treated in the selected chlorinated solvents: perchloroethylene (PCE), trichloroethylene (TCE), 1,1-dichloroethylene (1,1-DCE) and tetrachloromethane (TCM) at room temperature in a 2 L culture flask for varying treatment times. Residual liquids on the solvent treated fibres were removed by pressing under constant load between filter papers and immediately dried for 24 h in a vacuum oven preset at 60°C [18] except the 1,1DCE treated fibre that was dried at 27°C due to its low boiling point (31°C). The treated fibres were re-weighed and the amount of solvent retained was calculated in moles of liquid per kilogram of the dry fibre (mole/kg).

## 2.4. Laundering of Dyed PET Fibre in Selected Chlorinated Solvents

About 10-30 mg of dyed samples with known amount of Disperse Blue 1 dye uptake from a previous research work were weighed accurately into small conical flasks and were covered with about 20 ml of the chlorinated solvents; perchloroethylene (PCE), trichloroethylene (TCE), 1,1 dichloroethylene (1,1-DCE) and tetrachloromethane (TCM). The flasks were placed in a thermostatically controlled water bath at room temperature coupled with a mechanical shaker. The time for the first extraction was 10 min. The dye extracts were transferred into a 100 ml volumetric flask. The extraction procedure was repeated two more times at 10 min interval each, after which no more colour was transferred. The dye extracts were allowed to attain room temperature and were diluted up to mark with each of the solvents.

## 2.5. Determination of the Amount of Dye Removed

The concentrations of the dye extracts were measured spectrophotometrically using spectrometer 721 (2000 model) at 607 nm. The concentrations of the dye extracts were thereafter determined from the calibration curves of the disperse dye in each of the solvents.

## 2.6. Scanning Electron Microscopy (SEM) of Control and Treated PET Fibres

Scanning electron microscopy studies were made on treated and control samples with S-3000H- Hitachi, (Japan made machine) to study surface modifications caused by the laundering of the dyed PET filaments in the chlorinated solvents.

## 2.7. X-Ray Diffraction Studies (XRD)

X-ray diffraction studies using PAnalytical-mode X'pert PRO was carried out for both control and treated PET fibres to determine the percentage crystallization index of both the treated and control samples. The samples were analyzed by observing number of counts as a function of scattering angle (2θ).

## 2.8. FTIR Analysis

The infrared spectra were recorded on Fourier Transform- infrared spectrometer (Perkin-Elmer, Paragon 500 Model, UK) with built in spectra matching computerized software for surface analysis of both the treated and untreated PET fibres.

# 3. Results and Discussion

## 3.1. Critical Dissolution Time of the Treated Fibre

The results of the critical dissolution time (CDT) of the solvent treated PET fibres in 100% phenol at 60°C are represented on Figure 1. Generally, the CDT values of the treated fibres increase with increase in treatment time which may be as a result of changes in the crystalline structure of the fibres. The equilibrium CDT values (in sec) for TCM and PCE are 46 and 38 while 1,1-DCE and TCE have the same equilibrium value of 43. The values obtained for the solvent treated PET fibres are much higher than that of the control fibres (32 sec) because of greater stability conferred by the solvent treatment on the crystalline portion of the fibre. The CDT values of the solvent treated fibres were however; considerably lower than that of the heat set fibre at 85°C (Figure 2). The variations in the CDT values of heat and solvent treated fibres from Figure 1 and Figure 2 confirmed the claim by other workers [20] that different crystal morphologies were produced by these treatments: heat treatment on one hand leading to the development of few but large crystals that require longer time to dissolve and the liquid treatment on the other hand that produced relatively high amount of small crystallites that dissolve easily. Development of crystallites as a result of solvent treatment has been reported severally and the assumption was that the rate at which such crystallites dissolve is dependent on the concentration and size of the crystallites produced. The results obtained could therefore be related to the rate at which crystallization process on the treated fibres takes place.

The CDT values on Figure 1, showed a noticeable trend of TCM > TCE > 1,1-DCE > PCE, this may likely be a reflection of the extent of shrinkage the treatment might have caused. If the CDT results for TCM and TCE treated fibres are compared with that of heat set (Figure 2), the latter shows high values. For these three, however, the rate of energy (either chemical from solvent treatment or thermal (dry heat) for heat set) transfer into the fibre would be slow as observed with the values obtained for solvent treated fibres. It can therefore be posited that the large crystals which accompany the TCM and TCE treated

fibres are due to the slow development of the crystals leading to more stable and bigger crystallites whereas in the case of 1,1-DCE and PCE, more but smaller crystallites were formed because the rate of energy transfer is higher. The trend above could have been a complete reversal of increase in solubility parameter values of the solvents but for the change in position between PCE and 1,1 DCE. The change in the order between PCE and 1,1-DCE (against the expectation of using closeness of solubility parameter to that of the PET) can only be explained in terms of the molecular weights of the two solvents. PCE being of higher molecular weight of 166 g/mol migrates at slower rate than 1,1-DCE of 97 g/mol molecular weight and is also slowly desorbed out of the fibre leading to a net reduction in the available free space for crystal growth in PCE than 1,1-DCE.

## 3.2. Effect of Critical Dissolution Time on Stability of the Fibre

Since critical dissolution time (CDT) is a simple means of determining the stability of fibres to deformation after treatment, it would therefore be a critical indicator of the response of the fibre to the environment they may be exposed to both in processing and in use. The high CDT value of TCM treated fibres is an indication of better resistance to deformation compared to fibres treated with the other three solvents.
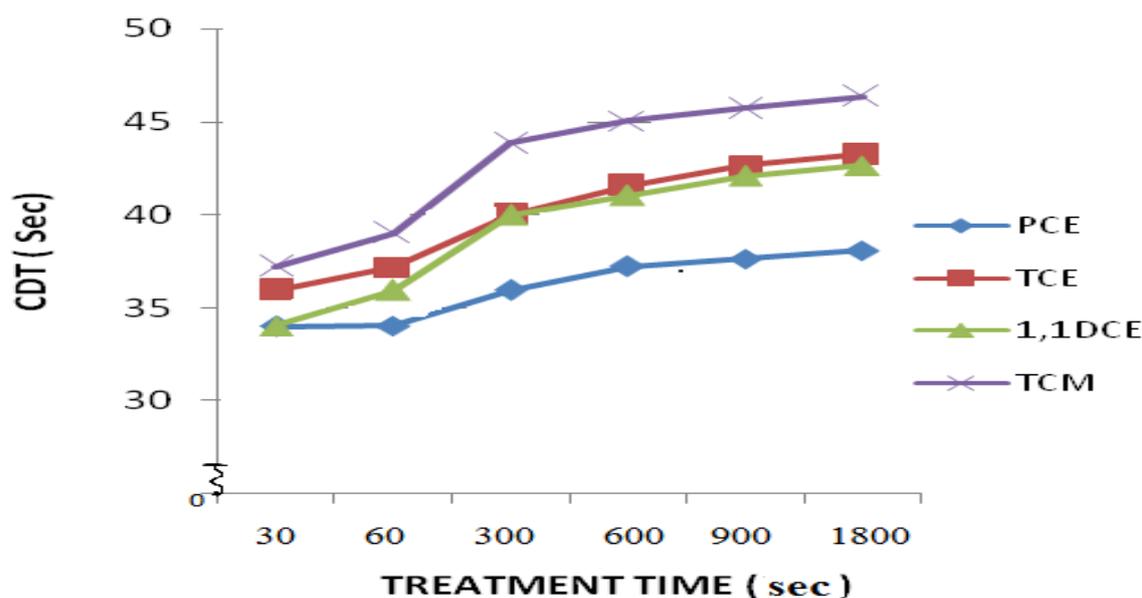


**Figure 1.** CDT of solvent treated fibres against treatment time (Note: Untreated fibre (CDT) = 32.00 secs)
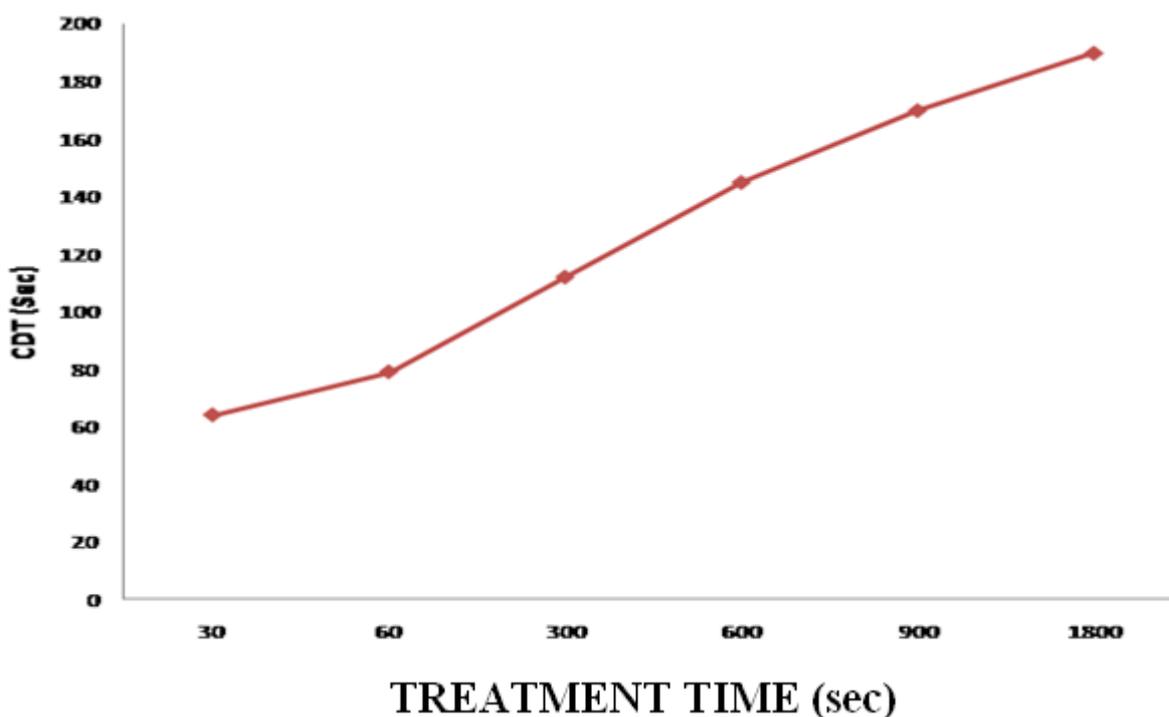


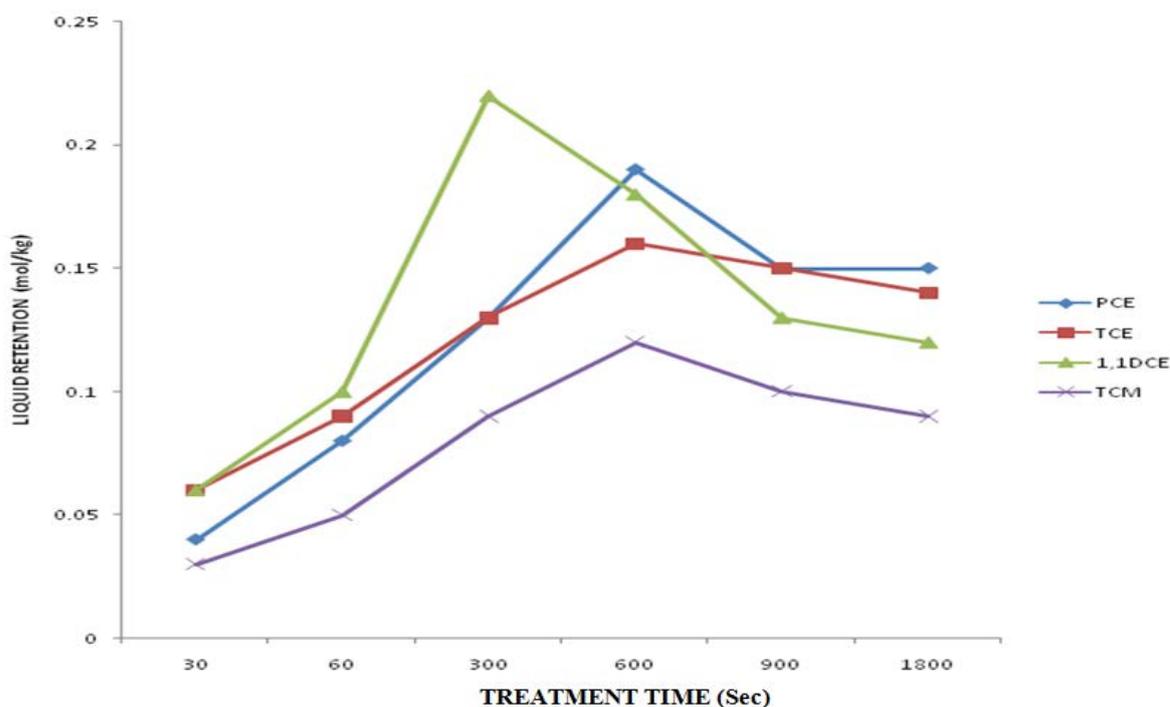**Figure 2.** CDT of heat set fibre at 85°C against treatment time

**Figure 3.** Solvent Retention of the Chlorinated Solvents and the Treatment time

## 3.3. Liquid Retention

The liquid retention study of PET fibre was done to determine the solubilities of the four-selected chlorinated solvents- perchloroethylene (PCE), trichloroethylene (TCE), 1,1-dichloroethylene (1,1-DCE) and tetrachloromethane in the polyethylene terephthalate (PET) fibre at room temperature. The results obtained on Fig. 3 showed that the results have a common feature of a rapid rise in the amount of liquid retained over a short period of time. TCM, PCE and TCE treated fibres showed maximum liquid retention at 600 secs and 1,1-DCE treated fibre within the first 300 secs of immersion.

From Figure 3, 1,1DCE gave the highest value of liquid retention of 0.22mol/kg. Other liquid retention values in mol/kg are PCE (0.19), TCE (0.16) and TCM (0.12). The trend of 1,1-DCE > PCE > TCE > TCM observed here showed that liquid retention (swelling) of a fibre could be directly related to the closeness of solubility parameter values of the solvents to the polymer at the same treatment time, it will be meaningful to infer that the plasticizing action of each liquid on the polymer is a function of both its solubility within the polymer and interaction efficiency of the liquid with it.

It was also observed from the results that TCM which showed the lowest liquid retention tendency among the treated fibres desorbed faster than other solvents with higher retention tendencies, 1,1DCE and TCE have the same liquid retention value of 0.06 mol/kg at 30 secs treatment time but 1,1-DCE reached its maximum liquid retention much earlier at 300 secs than TCE which occurred at 600 secs. PCE and TCE had the same value of liquid retention of 0.13 mol/kg on 300 secs treated fibres but had different maximum retention values of 0.19 mol/kg and 0.16 mol/kg at 600 secs treatment time and thereafter desorbed at the same rate to give 0.15 mol/kg and 0.14 mol/kg at 900 secs and 1800 secs treatment time respectively. Observations from above are indication of

similar morphological changes that took place within the polymer during those different treatment times. The initial increase in absorption of liquid to a maximum at 300 or 600 secs as the case may be for all the solvents was followed by a slow desorption which ultimately levels off to equilibrium at 1800 secs treatment time. Desorption of the liquids following a maximum in absorption could be accounted for in terms of crystallization of the polymer following its interaction with the liquids. This behaviour is expected to influence the subsequent mass uptake since liquid trapped within the crystallizing regions has to be expelled to allow for further crystallization and rearrangement into more perfect order. The liquid absorption and retention could then be seen to be a secondary process that is preceded by faster diffusion of the liquid into the polymer structure through the amorphous regions and the appreciable crystallization that followed the liquid uptake therefore did not inhibit the liquid uptake that preceded it. The low amount of the four chlorinated solvents retained by the fibres compared to higher values from literature [19] could be attributed to either the "closing up" of the polymer structure i.e. decrease in the free volume accessible to liquid molecules within the polymer as a result of the heat treatment which the fibre has been made to undergo prior to retention study to ensure adequate removal of moisture that may influence the process or due to the fact that the amount of liquid uptake was based on the actual increase in weight of the fibre (after the non- interactive, adhering organic solvents have been removed) and not on mass uptake of the liquid irrespective of whether it was absorbed or not.

## 3.4. Effect on Liquid Retention on Dimensional Stability of Polyester Fibre

To many materials, temperature and humidity are critical factors to the degree to which the material maintains its

original dimensions when subjected to environmental changes. The high liquid retention values of 1,1-DCE, PCE and TCE is an indication of high amount of fibre swelling, which if not controlled, definitely will have an unwelcome implication such as fibre instability compared to the TCM treated fibres with anticipated higher anti-swell efficiency due to its lower liquid retention ability and the TCM treated fibres are therefore expected to be more stable after the treatment than those from the other three solvents.

## 3.5. IR Spectra

From the IR spectra obtained for the TCM, TCE, PCE, 1,1-DCE solvent treated and the untreated fibre, it is worthy to note that there is no destruction of peaks or formation of new ones which may corresponds to the

other functional groups and this infers that the solvents does not chemically modified the polymers.

## 3.6. Surface Dye Wash

The results of the amount of surface dye removed after laundering the dyed fibres in the four chlorinated solvents are presented in Table 1. The rate of removal of surface dye from the dyed fibres was found to increase with increase in treatment time until a near equilibrium values were achieved at 900 seconds for all the fibres and the amount of dye removed showed a trend of TCM > 1,1-DCE > TCE > PCE. From the Table, the rate of desorption (rate of extraction) was also found to increase with increase in treatment time until a near equilibrium values were reached at 900 secs for all the fibres.
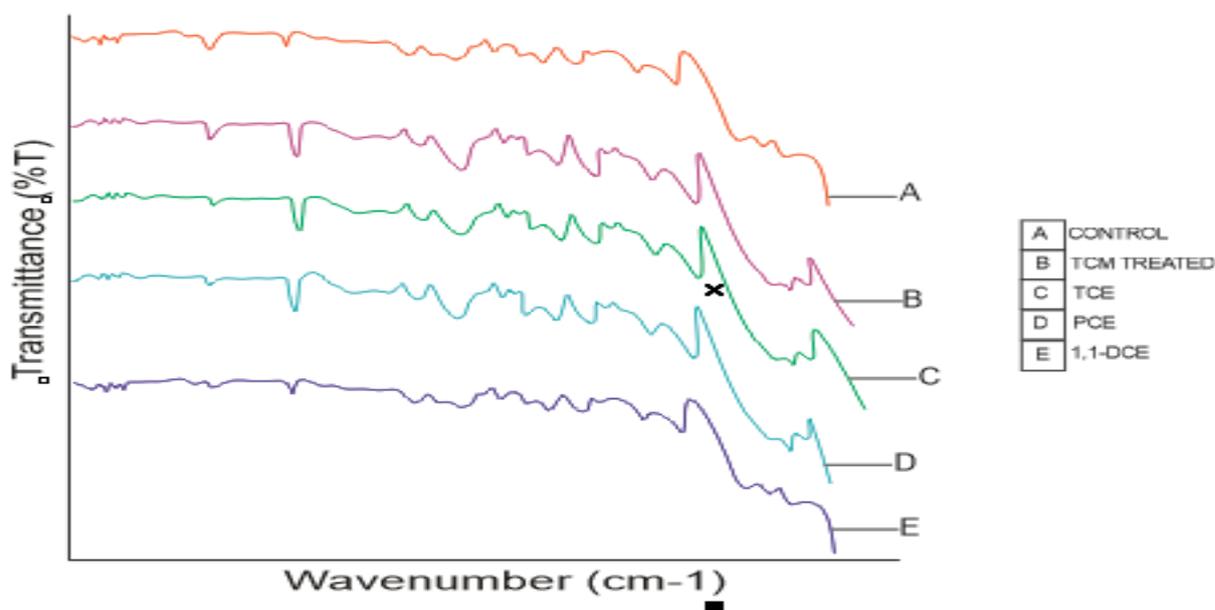


**Figure 4.** IR Spectra of Control and 30s solvent Treated Fibre in TCM, TCE, PCE and 1,1-DCE

**Table 1. Amount of Dye Removed after Laundering of the Dyed Fabric in the Selected Chlorinated Solvents**

| Treatment Time (sec) | Dye removed (mg/g) | | | |
|---|---|---|---|---|
| | PCE | TCE | 1,1- DCE | TCM |
| 30 | 18.6[a] (69.93) | 11.3 (120.12) | 13.8 (73.80) | 23.7 (49.38) |
| 60 | 20.9 (164.84) | 22.0 (190.48) | 17.5 (132.45) | 37.0 (100.00) |
| 900 | 35.4 (317.46) | 37.5 (343.98) | 49.6 (323.53) | 56.4 (211.86) |
| 1800 | 36.4 (318.30) | 39.0 (343.98) | 51.1 (324.45) | 58.3 (212.20) |

Note
[a] are the amounts of dye stripped by the chlorinated solvents.
Values in parentheses are the amounts of dye uptake (mg/g) by the PET fibre. Oyeleke *et al.,* [20].

The dye wash was done at room temperature because the use of high temperature is likely to degrade the dye, solvent or may even cause crystal modification in the polymer which may lead to erroneous results. The ability of a solvent to swell and to bring down the Tg of the polymer depends on the closeness of solubility parameters of the solvent and the polymer. Accordingly, for extraction of dyes from the surface of polyester, Madan and Khan, [16] suggested that, the solubility parameter of the solvent should be close to that of the polyester (10.7) and hence, the solvents which has solubility parameters close to this value (such as those of 1,1-DCE -9.76, PCE -9.30 and TCE -9.28) should swell the fibre on one hand and

dissolve the dye on the other. Data obtained on Table 1, negates this, because the three chlorinated solvents above were able to remove little amount of the dye from the surface of the fibre despite the closeness of their solubility parameter values to that of the dye and the fibre because the partition coefficient will be low and the dye will lack preference for dissolution in the solvents which possibly makes the extraction of the dye difficult. Alternatively, the fine structural differences which provide increased internal surface by more opening up for deposition of more dyestuff may have collapsed at the dyeing temperature thereby trapping the dyestuff inside and making it difficult for the dye to be removed.

TCM as solvent gave the highest value of dye wash from the surface of the dyed fibre which may be explained in terms of its wider solubility parameter value range of 8.65 to that of PET (ca. 10.7) compared to the other three solvents with closer solubility parameter values, this will correspond to a system in which the diffusion coefficient of the dye is extremely low and the partition coefficient, high. In this case, the surface dye would be leached out easily in favour of the solvent such as the case with TCM. It is therefore important to note that removal of dye from fibre may not follow exactly the increase in solubility parameter principle as expected; though it may be a useful guideline in choosing a series of solvents for the purpose. One other important factor that may likely play an important role is partition coefficient of dye between fibre and solvent. Conclusively, the ability of these chlorinated solvents (especially TCM) to remove surface dye at room temperature suggests their usefulness in reduction clearing of surface dye and can be utilized in levelling an unevenly dyed fabric after the normal dyeing process. Since this process is effective against excess surface dyes, the phenomenon can also be employed in removing solvent borne stains from the surface of textile materials thereby improving the wearing ability of the material because tiny crumbs (if not removed from fibre surface) can attract insects and cause damage to the material and the excess dyes and stains if bonded to the textile material for a long time can break down the fibre thereby shortening the lifespan of the fabric as well as discolouration of the textile material. TCM will therefore be a very important solvent in cleanability of fabrics during dry cleaning process.
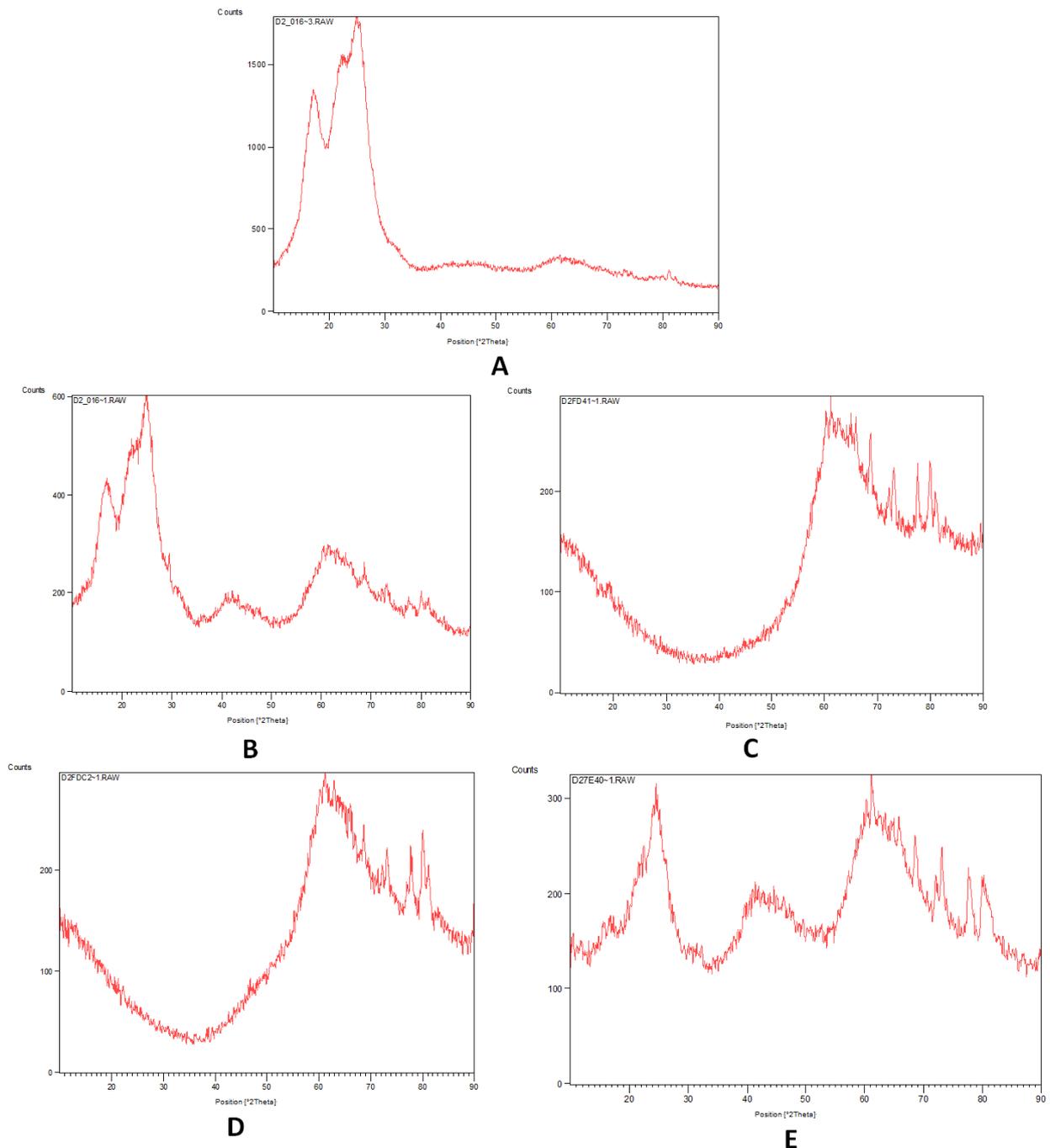


**Figure 5.** XRD of Control (A) and Dyed PET Fibres Laundered with PCE (B), TCE (C), 1,1-DCE (D) and TCM (E)

## 3.7. Surface Characterization of the Dyed PET Fabric Laundered in the Chlorinated Solvents

### (a) X-Ray diffractographs

X- ray diffractographs (XRD) of treated fibre and dyed fabric laundered in the chlorinated solvents were shown on the attached Fig 5. The little decrease and deformation in the diffraction areas of the laundered fabric compared to the untreated may be due to the fact that the smaller crystallites produced must have been partially dissolved during laundering and this is in line with the findings of Bal and Behera, [21]. This observation does not actually show any significant adverse effects on the surface of the polyester fabric as revealed by the SEM which may not be unconnected with low liquid retention values obtained for the treated samples.

### (b) Scanning Electron Micrographs

The surfaces of the dyed fabric laundered in the chlorinated solvents at magnification of 500X were as shown on Plate 1. Apart from the dye removed, the scanning electron micrographs of the laundered fabric do not reveal any further significant surface damage on the fabric. This characteristic will make these solvents useful in dry cleaning activities especially the delicate ones that are liable to be damaged during the normal cleaning process.
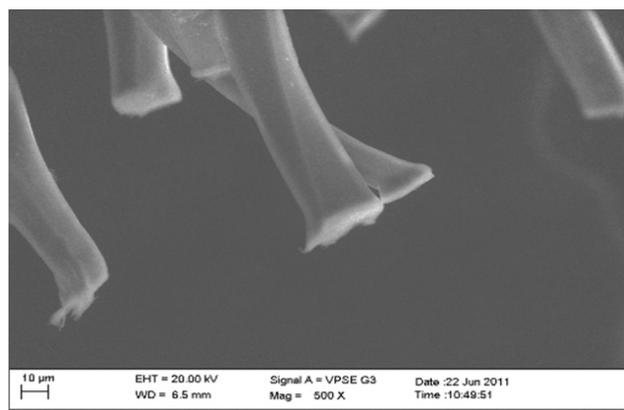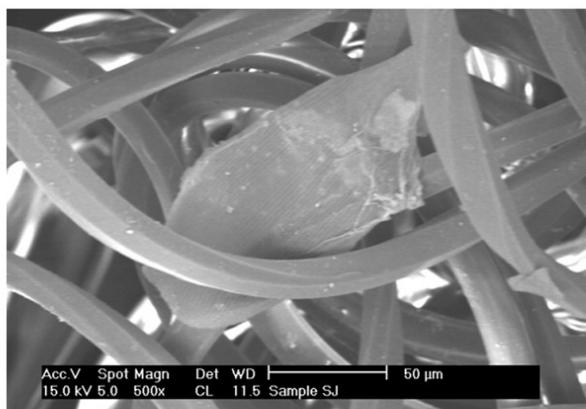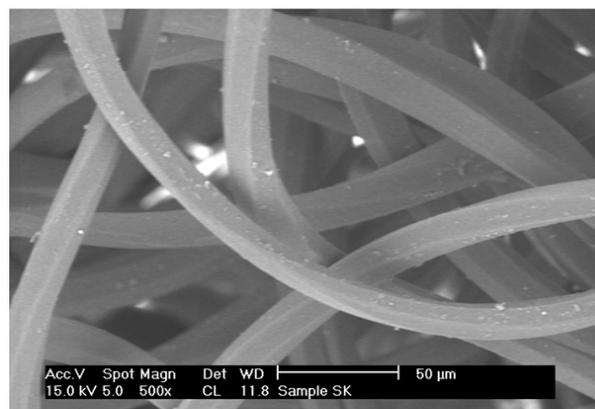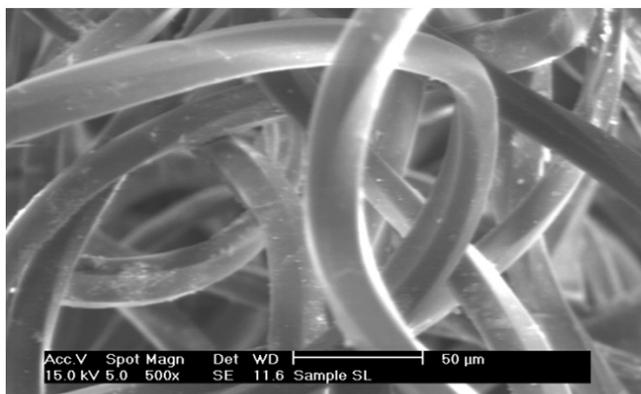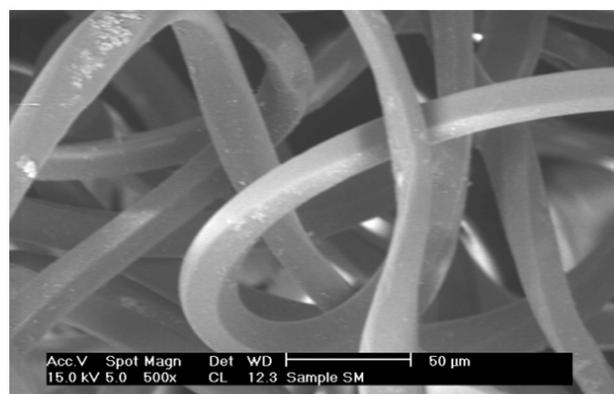


**Plate 1**. SEM of Control (A) and Dyed PET fibres Laundered with TCE (B), PCE (C), 1,1-DCE (D) and TCM (E) at 500X

# 4. Conclusion

The outstanding dimensional stability of the treated fibres (especially TCM treated fibre) in terms of its minimal swelling ability both in thickness and width as observed from the results of X-ray diffractographs, scanning electron micrographs (SEM) and low liquid retention value revealed that the solvents can be confidently used in applications where the textile fabric is expected to encounter varying liquid or moisture conditions without the fear of deforming or damaging through swelling. This condition therefore, conferred better resistance to water and solvent borne stains on the solvent treated fibres. The superior deformation and dimensional stability of TCM treated fibres will be of particular importance during the process of solvent cleaning of the polyester fabric where the material is expected to become wet. The result of SEM analysis is an indication that the laundered PET fabrics will have good shape, better dimension retention ability and excellent resistant to these chlorinated solvents during laundry services. The research work therefore revealed the usefulness of the four chlorinated solvents especially TCM in fabric surface cleaning (FSC), surface stain removal (SSR) and dye wash (DW).

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